CROP DEPREDATION BY WILDLIFE ALONG THE EASTERN BOUNDARY OF THE KALAKAD-MUNDANTHURAI TIGER RESERVE, SOUTHERN INDIA[1]

(*With two text-figures*)

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Key words: *Sus scrofa cristatus*, wild pigs, crop loss, crop raid, human-wildlife conflict, electric fence

Crop raiding patterns by wildlife at ten villages along the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve (KMTR), southern India were studied. The Indian wild pig (*Sus scrofa cristatus*) was identified as the major crop pest in this area and the crop loss caused by it was quantified. The effectiveness of an electric fence to prevent crop raids by wild pig was also assessed, comparing (1) mean group size of pigs, (2) extent of damage in sq. m, (3) actual and potential loss, and (4) frequency of wild pig raids. The actual loss was estimated at 257.19 kg ha^{-1} accounting for approximately 7% of the actual produce. The electric fence was not effective in preventing crop raiding by the wild pig. The number of wild pigs was not correlated with the extent of damage. Extent of damage might be a factor of time spent in the paddy field, suggesting that wild pigs might raid paddy fields for habitat requirements rather than for nutritional requirements. It is vital to understand crop-raiding patterns prior to the implementation of control strategies.

INTRODUCTION

Strategies for reconciling human needs and conservation interests in areas abutting nature preserves are critical to the success of conservation plans (Gradwohl and Greenberg 1988, Western and Pearl 1989). Crop depredation by wildlife can occur more frequently than the highly publicized and prioritized, but sporadic livestock raids. Over the years, farmers have developed a variety of measures such as fencing, culling, dogs, firecrackers, fire and drums to chase away pest species and reduce crop loss to wild animals. Today, when many crop raiding species are protected by law and are focal points for conservation, the need for effective and long-term control methods is felt. Some of the control measures include physical barriers, selective culling and environmental control methods, such as providing better habitat in the forest interiors, away from human habitation (Sukumar 1992). Recently, electric fencing has become one of the methods widely used by both private farmers and the government to prevent crop raids by wild animals.

In a predominantly agricultural and densely populated country like India, conflicts between humans and wild animals are frequent, and preventing conflict should be a conservation priority (Sukumar 1992). Damage by the Asian elephant *(Elephas maximus*) has been estimated at *c.* $0.5 million/per year in southern India (Sukumar 1989). Although considerable work has been done on the crop damage patterns and management strategies for larger wildlife, such as the elephant and tiger (landmark studies include Sanyal 1987, Sukumar 1991), work on wild pigs is sparse, except for Tisdell (1982), and Ahmed (1991).

Crop damage patterns along the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve by different wildlife species and wild pigs in particular were analyzed and crop loss due to wild pigs, the major pest in the area, were

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estimated. The study also attempted to understand the possible cues for crop raiding by the wild pig in the area, and to suggest effective control measures. An electric fence, erected with the aid of the World Bank, was assessed for its effectiveness against the wild pig.

Study Area

The study was carried out from December 1998 through March 1999 in ten villages located in the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve (KMTR), southern India. KMTR is situated at 08° 25' - 08° 35' N and 77° 25' - 77° 35' E and covers 795 sq. km of the southernmost protected area in the Western Ghats complex. Along the northeastern boundary of the Reserve, an 8.7 km long electric fence was erected in 1996 with partial funding from the World Bank to control crop damage by wildlife (Fig. 1). The fence is about 160 cm high and consists of 7 wires running parallel to the ground attached to granite posts at intervals of 2.5-3 m. Wires 2 and 5 are ground wires. The rest of the wires have an output of 36V generated from a 12V solar battery. The lowest wire is *c.*10 cm from the ground and the second wire (earth wire) is *c.* 30 cm from the ground.

Ten villages located along the 26 km eastern boundary of the KMTR were selected for the study. Four villages were located in the Mundanthurai area and were separated from KMTR by the electric fence. The fifth village abutting the Mundanthurai section (Pudukudierrupu) was not protected by an electric fence. The other five villages bordered the Kalakad section of KMTR (Fig. 1). All the study villages had lowland teak dominated deciduous forests, thickets, and scrub jungles, representative of the vegetation of the buffer zone of KMTR. All the crops grown along the boundary, such as paddy, banana, sugarcane, and groundnut, were also cultivated in the 10 study villages (Table 1).

Table 1: Details of the Study Villages

S.No	Village	Vegetation type adjoining the village	Electric Fence
1.	Pothigaiadi	Secondary Thicket	*
2.	Anavankudierrupu	Secondary Thicket	*
3.	Kilanai	Secondary Thicket	*
4.	Arunachalapuram	Secondary Thicket	*
5.	Pudukudierrupu	Rocky/ Grassland	x
6.	Sivapuram	TDDD	x
7.	Mungiladi	Secondary Thicket	x
8.	Manjuvelai	TDDD	x
9.	Kalliyar	TDDD	x
10.	Chidamparapuram	Secondary Thicket	x

TDDD = Teak Dominated Dry Deciduous, Present - *, Absent - x

Methods

Farmers' Perceptions

A questionnaire was circulated among farmers in the 10 study villages to estimate wildlife raids, crop loss, and other relevant information. Results from the questionnaire indicated the actual or realized yield and crop loss due to wild pigs. Potential yield and crop loss estimates were based on quadrat data. Both the questionnaire as well as quadrat data were used to estimate crop loss because farmers tended to underestimate production and overestimate crop loss due to wildlife.

Crop Raids

Information regarding the wildlife species involved in the raid, group size, and the time of raid were obtained from the farmer who had witnessed the raid or through direct observation. The species responsible for the highest proportion of raids and damage in the area was identified as the major crop pest species.

Crop Damage

Crop damage was assessed within 24 hrs of the damage. The site was visited, and the mean plant density (MPD) was estimated to assess crop loss. MPD measurements were determined in the

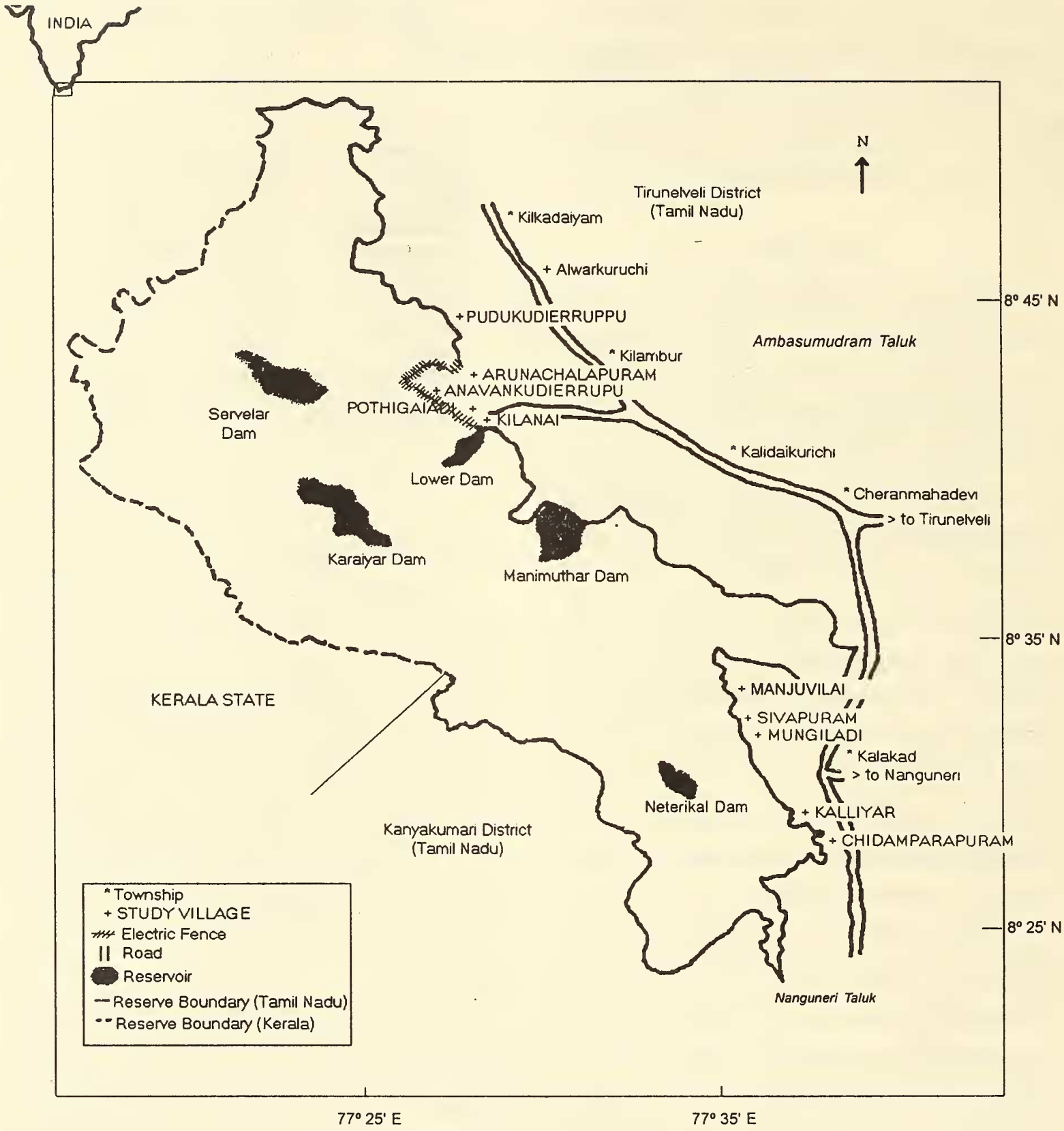

Fig. 1: Kalakad-Mundanthurai Tiger Reserve

damaged and undamaged sites in the field. MPD was estimated by laying 12-30 quadrats (30 cm x 60 cm) at random in the undamaged part of the field. The field area was noted. The total number of plants in the field (P_u) was estimated by

P_u = MPD x Area of the field in sq. m (Eq 1)

A sample of five plants was taken from each quadrat for which the number of grains and mean weight per grain were calculated.

The damaged area was identified as the portion of the field where all the stalks had been

flattened to the ground and could not be harvested. The average length and width or radius within the damaged areas were measured and the area of the closest resembling regular shape, i.e., square, rectangle, or circle was calculated in sq. m. The total number of damaged plants (P_d) was calculated using the formula

P_d = MPD x damaged area in sq. m(Eq 2)

The number of grains per damaged plant was counted and weighed. The potential produce (standing crop) was estimated by

$$P_p = P_u N_g W_g / 1000 \text{(Eq 3)}$$

where, P_p = Potential produce in kilograms,
P_u = total number of plants in the field,
N_g = mean number of grains per plant, and
W_g = mean weight of one grain in grams.

The potential loss (P_l) in kilograms due to crop damage can be estimated by

$$P_l = P_d N_g W_g / 1000$$

where P_d = total number of damaged plants

The average actual produce (kilograms of paddy sold by the farmer in the market) was estimated using the farmer's claim and a brief survey of the buyers. The market value of the crop was obtained from the farmers and wholesalers to arrive at the actual loss in kilograms and rupees. The potential loss was the loss measured during this study based on the yield measured by the quadrat study. Loss per raid thus calculated was used to extrapolate the loss for a month using the mean number of wild pig raids in each of the ten study villages.

Effect of the electric fence

The villages were divided into villages protected by an electric fence and unfenced villages. A t test or its non-parametric equivalent, the z test, was used to test for significant differences between the two in the following parameters:

1. Mean group size of pigs.
2. Extent of damage in sq. m.
3. Actual and potential loss.
4. Frequency of wild pig raids.
5. Frequency of larger wildlife sightings on cropland.

RESULTS

Crop raiding patterns

A total of 121 farmers were interviewed, and 39 instances of fresh crop raids were observed. Of these, 35 were on paddy fields, 3 on banana plantations and 1 on sugarcane. The results show that of the 11 species of crop pests reported, wild pigs were the most and accounted for 99% of the crops damaged during the study (Table 2). Crop raiding patterns of wild pigs on paddy were dependent on the age of the crop (Ahmed 1991, Jeyasingh 1999). The ears of paddy were nipped off, chewed well, the juice ingested and the fibre spat out. In banana plantations, wild pigs fed on the stem, flower, and fruit by reaching up on their hind legs and biting the stem to bring down the canopy. On younger plants, they nosed around the plant to expose and feed on the tender shoot. Sugarcane stems were consumed voraciously from the bottom for the juice and fibre.

Other wildlife reported to stray outside the Reserve boundary included larger herbivores like the sambar (*Cervus unicolor*), chital (*Axis axis*), Asian elephant (*Elephas maximus*) and carnivores such as leopard (*Panthera pardus*), wild dog (*Cuon alpinus*) and sloth bear (*Melursus ursinus*). Apart from these, smaller mammals such as black-naped hare (*Lepus nigricollis*), common palm civet (*Paradoxurus hermaphroditus*) and the jungle cat (*Felis chaus*) were also sighted (Table 2).

Data on wild pigs only, the major pest on paddy crop, was considered for analysis. The frequency of wild pig raids in the ten study villages was proportional to the area of land under cultivation (Table 3). The mean number of crop raids per month by wild pigs in the fenced

Table 2: Wildlife raids on croplands in 1998-99 in the ten study villages

Common name	Local name	Latin name	IUCN Status	Number of sightings	Villages	
					F	UF
Leopard	Puli	*Panthera pardus*	EN	4	1	3
Wild dog (Dhole)	Chen Nai	*Cuon alpinus*	EN	2	1	1
Sloth bear	Karadi	*Melursus ursinus*	EN	6	1	5
Sambar	Mila Maan	*Cervus unicolor*	LR/CD	14	4	10
Chital	Pulli Maan	*Axis axis*	LR/CD	4	1	3
Black-naped hare	Muyal	*Lepus nigricollis*	DD	12	5	7
Jungle cat	Kattu Punai	*Felis chaus*	VU	86	54	32
Common palm civet	Mara Nai	*Paradoxurus hermaphroditus*	VU	3	3	0
Bonnet macaque	Korangu	*Macaca radiata*	VU	7	6	1
Indian wild pig	Kattu Panni	*Sus scrofa*	LR/CD	121	68	53

IUCN = International Union for Conservation of Nature and Natural Resources, F = Fenced villages, UF = Unfenced villages, EN = Endangered, LR/CD = Low risk/ conservation dependent, VU = Vulnerable, DD = Data deficient

villages was 21.80 and 22.54 in unfenced villages (Table 4). The mean group size was about 11 animals in each category (Table 4). The crop loss between the fenced and unfenced villages was not significantly different (Table 4).

The regression between the number of wild pigs and damaged area was not significant ($r^2 = 0.09$), suggesting that the extent of damage was not dependent on the number of pigs involved in the raid.

Economic value of crop loss

The overall crop damage in all the villages studied was estimated to be Rs. 16,270.65, at Rs. 4.40 per kg of paddy (Ministry of Agriculture, Govt. of India) in all the ten villages during the study. The approximate loss of paddy to wild pigs was 7% of the actual produce in all the villages (Fig. 2). Potential and actual yield were estimated at 5270.29 kg ha^{-1} and 3697.93 kg ha^{-1} respectively. The potential loss was estimated at 366.56 kg ha^{-1} and the actual loss was 257.19 kg ha^{-1} (Fig. 2).

Effects of the electric fence on crop loss

There were frequent large mammal sightings in the unfenced villages compared to the fenced villages (Table 2). The mean quantity

Table 3: Sampled area and estimated crop loss per village

Village	No. of raids studied	Area of the Field (m^2)	Damaged Area (m^2)	Estimated Potential Produce (kg)	Loss in kg	Loss per raid in kg
Sivapuram	4	928.2	69.405	632.77	44.85	11.21
Chidamparapuram	4	617.5	43.65	530.75	33.95	8.48
Mungiladi	3	183.93	30.54	132.71	22.04	7.34
Kalliyar	2	125.6	28.05	106.10	13.51	6.75
Manjuvelai	4	713	63.42	626.94	57.91	14.47
Pudukudierrupu	3	1450.8	68.52	714.03	31.50	10.5
Anavankudierrupu	5	655.05	50.84	583.45	50.12	10.02
Pothigaiadi	5	123.2	67.26	1387.3	71.88	14.37
Kilanai	3	172.5	26.08	143.7	21.49	7.16
Arunachalapuram	2	424.14	15.32	355.42	12.81	6.4

of paddy lost per pig raid in fenced villages was 9.48 kg, with Pothigaiadi recording a maximum of 14.376 kg/raid. In the unfenced villages, the mean loss was estimated at 9.65 kg/raid, with Manjuvelai recording the highest at 14.47 kg/raid (Table 3).

There was no significant difference ($P = 0.05$) in the loss estimates, raiding frequency, and wild pig group size between the fenced and unfenced villages during the study period (Table 4).

Discussion

The study indicated that the wild pig was the major crop pest along the eastern boundary of the Kalakad-Mundanthurai Tiger Reserve. The wild pig causes significant damage to paddy, the major crop in the study area, accounting for about 7% of the actual yield. The extent of loss might vary, depending on the season and the year. The crop is damaged as the wild pigs wallow in the abundant mud and water in paddy fields. They consume the grain at only one stage, the 'milk maturity stage'; otherwise they do not eat any part of the paddy plant (Ahmed 1991, Jeyasingh 1999).

The Indian wild pig is a forest loving omnivorous mammal. Its diet includes roots, tubers, bulbs, fruit, insects, molluscs and remains of tiger and wild dog kills (Prater 1980, Tisdell 1982, Seshadri 1986). As it does not have sweat glands, the wild pig must drink regularly and wallow to regulate body temperature (Ahmed 1991). Therefore, it requires water sources, especially during the hot season. It prefers to remain in the shade of reeds and shrubs, which help in thermal regulation, and prefers open canopy and dense undergrowth at night (Tisdell 1982). It is crepuscular, although in areas where human interference is high, it is known to become nocturnal (Prater 1980). The home range of a sow tends to be 5-30 sq. km and that of a boar about 50 sq. km. The boar is mobile

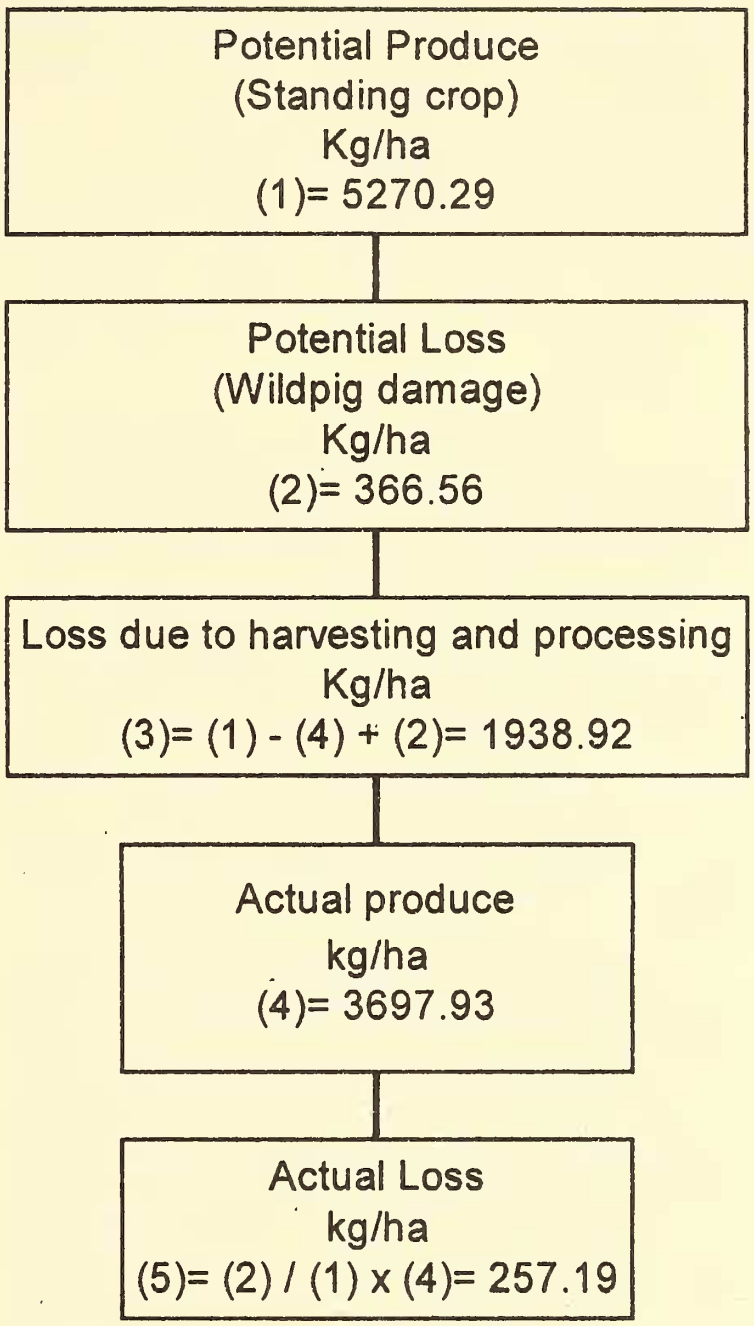

Fig. 2: Schematic representation of loss calculations

and is known to move long distances for food and mating opportunities (Prater 1980, Tisdell and Fadeer 1981). Group sizes vary with climatic conditions and a sounder of 10-15 individuals is common (Brander 1923, Prater 1980).

Until the 1960s, forests adjoining the study villages were disturbed periodically: clear cutting deciduous forests and planting commercially important species, construction of dams, intense cattle grazing and frequent fires (Joshua and Johnsingh 1989). As a result, plant species composition is dominated by fire resistant and

Table 4: Difference between raid frequency, group size of wild pigs and crop loss in fenced and unfenced villages

Parameter	Fenced			Unfenced			95% C I	Z	P= 0.05
	N	Mean	SD	n	Mean	SD			
Frequency	49	21.80	3.60	59	22.54	4.53	0.74 ±1.53	0.9526	*
Group size	45	11.27	7.05	56	11.26	7.53	0.01 ±2.85	0.2158	*
Crop loss	16	9.48	5.86	19	9.65	6.87	0.33 ±3.13	0.1078	*

* - not significant

highly silicified species (Johnsingh 1986). Moreover, the two major reservoirs within the Reserve, Karaiyar and Servalar may desiccate all potential wild pig wallows along the rivers inside the Reserve. The non-significant regression between number of pigs and extent of damage suggests that the extent of damage might be a factor of time spent in the cropland, suggesting that wild pigs might prefer the paddy fields mainly for the ambience rather than for forage.

The 8.6 km long electric fence erected with World Bank aid in 1996 does not appear to be effective against the major crop pest. There was no significant difference in raiding patterns of wild pigs and crop loss between the fenced and unfenced portions of the Kalakad-Mundanthurai Tiger Reserve's boundary. It is apparent that the fence was designed to deter larger mammals such as the elephants, sambar and chital. This might be because the fence is designed in such a manner that there is a gap of 40 cm (approximate to 10 different places in the fence) between the lowest live wire (first wire) and the next live wire (third wire), making it possible for smaller animals to slip through. Moreover, the second wire at about 30 cm from the ground is an earth wire, which might enable the larger pigs to penetrate the fence without getting an electric shock. We suggest that the gap between the three lower wires be reduced to eliminate penetration by wild pigs. The scrub dominated hills and private irrigation canals along the border are refuges for the sounders of wild pig once they are outside the fence.

It is evident that the fence has not been designed to control the wild pig. Preliminary studies must be carried out before a control or management project is conducted. The success of such a venture depends on its effectiveness in reducing crop damage by wildlife. The project should be monitored to assess its effectiveness. If crop damage continues despite such a project, it may create distrust among villagers towards the Forest Department, reducing their goodwill towards conservation efforts in the area. Human use of the landscape is a reality and must be dealt with in reserve design (Kramer *et al.* 1997), the importance of people in the success of conservation schemes has been stressed in both developed and undeveloped countries (McNeeley and Norgaard 1992, Kothari *et al.* 1996). It is suggested that the wild pig raids reported in this study be controlled as soon as possible, before local villagers completely lose faith in the forest department. It is further recommended that suitable habitats such as wallows be created within the Reserve for wild pigs, and wild pig incidence in cropland be tested after such environmental control measures.

Crop loss to wildlife in a country like India is a bane for conservation efforts, where farmers compete with wildlife for space and resources. Quantifying crop loss and identifying the cues for wildlife to raid crops are vital in developing efficient conservation strategies. Correct management and control measures are needed to ameliorate the economic loss incurred due to wildlife, and to cultivate conservation awareness among local communities.

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